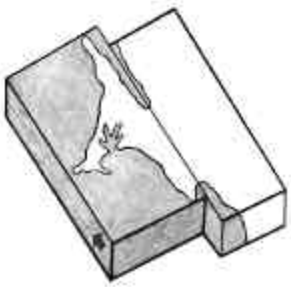
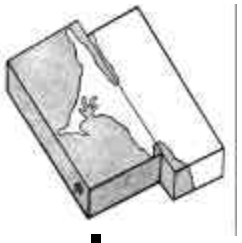
Creating
COASTAL
STEWARDSHIP
through Science



Uncovering the San Andreas Fault

On-Site Activities

What Makes the Geology of Point Reyes National Seashore So Special? 49
What Does a Fault Zone Look Like? 87



What Makes the Geology of Point Reyes National Seashore So Special?

Students will walk the Earthquake Trail which is near what was once believed to be the epicenter of the 1906 earthquake. This trail has interpretive signs describing the geologic significance of the area. Students will answer questions in their field journals so they may gain the greatest appreciation of how clues on the land can tell a geologic story.

Time required: 2 hours
Location: Earthquake Trail (near Bear Valley Visitor Center)
Suggested group size: up to 50 walking on trail
Subjects: earth science, math, writing
Concepts covered: transform faults, plate tectonics, earthquake processes, earthquake preparation, rocks of Marin County
Written by: Mike Schulist
Last updated: 04/10/00

Student Outcomes

At the end of this activity, the students will be able to:

- Explain the major forces that create earthquakes
- Explain the role of plate tectonics in Point Reyes geology
- Name some of the local rock types in Marin County

California Science Standards Links (grades 6-8)

This activity is linked to the California Science Standards in the following areas:

6th grade
1a - the fit of the continents, location of earthquakes, etc., provide evidence for plate tectonics
1b - the solid earth has three layers
1c - lithospheric plates that are the size of continents and oceans move at rates of centimeters per year in response to movements in the mantle
1d - earthquakes are sudden motions along breaks in the crust called faults
1e - major geologic events, such as earthquakes, volcanic eruptions, and mountain building result from plate tectonics

On-Site Lesson Plan

Creating Coastal Stewardship through Science

1f - explain major features of California geology in terms of plate tectonics (including mountains, faults, volcanoes)
1g - how to determine the epicenter of an earthquake and that the effects of an earthquake vary with its size, distance from the epicenter, local geology, and the type of construction involved
7b - select and use appropriate tools and technology to perform tests, collect and display data
7h - identify natural changes in natural phenomena over time without manipulating the phenomena

7th grade 7a - select and use appropriate tools and technology to perform tests, collect and display data

8th grade 9b -evaluate the accuracy and reproducibility of data

National Science Standard Links (grades 5-8)

This activity is linked to the National Science Standards in the following areas:

- Content Standard A - Use appropriate tools and techniques to gather, analyze, and interpret data; understanding about scientific inquiry.
- Content Standard G - Science as a human endeavor; Nature of science: students formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models.

Materials

To be provided by the student:

- comfortable shoes
- pen/pencil
- flat surface to write on (clipboard/binder)

To be photocopied from this guide:

- Field journals for each student, teacher, and chaperone

Vocabulary

earthquake, epicenter, fault zone, Franciscan sandstone, granite, greenstone, lithosphere, serpentine, topography, transform fault

Procedures

1. **Bear Valley Visitor Center**
   Start your field trip at the Bear Valley Visitor Center which is within walking distance of the Earthquake Trail. The Visitor Center contains displays on the National Seashore, a video program, public restrooms, and drinking water. You may want to especially call attention to the working seismograph which students can watch in operation.

   You may borrow the following teaching materials from the Visitor Center: Geology Backpack, binoculars, spotting scope, and/or clipboards. Remember to have one group start on the Trail and finish with the Visitor Center activity and the other group do the reverse. This frees up space on the trail and prevents crowding in front of the trail signs.

2. **Earthquake Trail**
   Students walk the Earthquake Trail, stopping to read each informational sign and answering related questions on their worksheet. It is important for students to answer these questions while they are on the trail rather than waiting until they are back in class. **The most important display on the trail is the displaced fence.** This is visible evidence of the San Andreas Fault, of plate tectonics, and one of the best places in the surrounding area for students to truly understand the relationship between their surroundings and earthquakes.

Things to Remember While on Geology Field Trip

Three safety precautions:

1. _____

_____

2. _____

_____

3. _____

_____

Four resource protection behaviors:

1. _____

_____

2. _____

_____

3. _____

_____

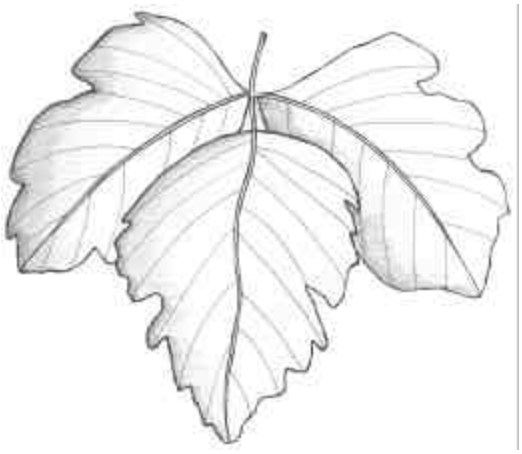
4. _____

_____

Watch Out for These Three Things...

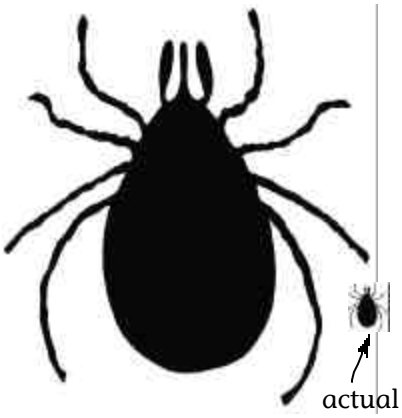
Stinging nettle

Stinging nettle is a tall plant with needlelike hairs, which can create a burning or stinging sensation for up to 24 hours. If you see this plant, do not touch it.



Poison oak

Poison oak has three smooth, shiny leaflets which are bright green or reddish. It can grow up trees as a vine, as a small bush, or as a small ground cover plant. Poison oak causes an itchy, blistering irritation which can last for one to two weeks. Even when leaves are not present, it is possible to get poison oak. Wash all skin and clothing that may have come in contact with poison oak with cool water and a grease-cutting soap.



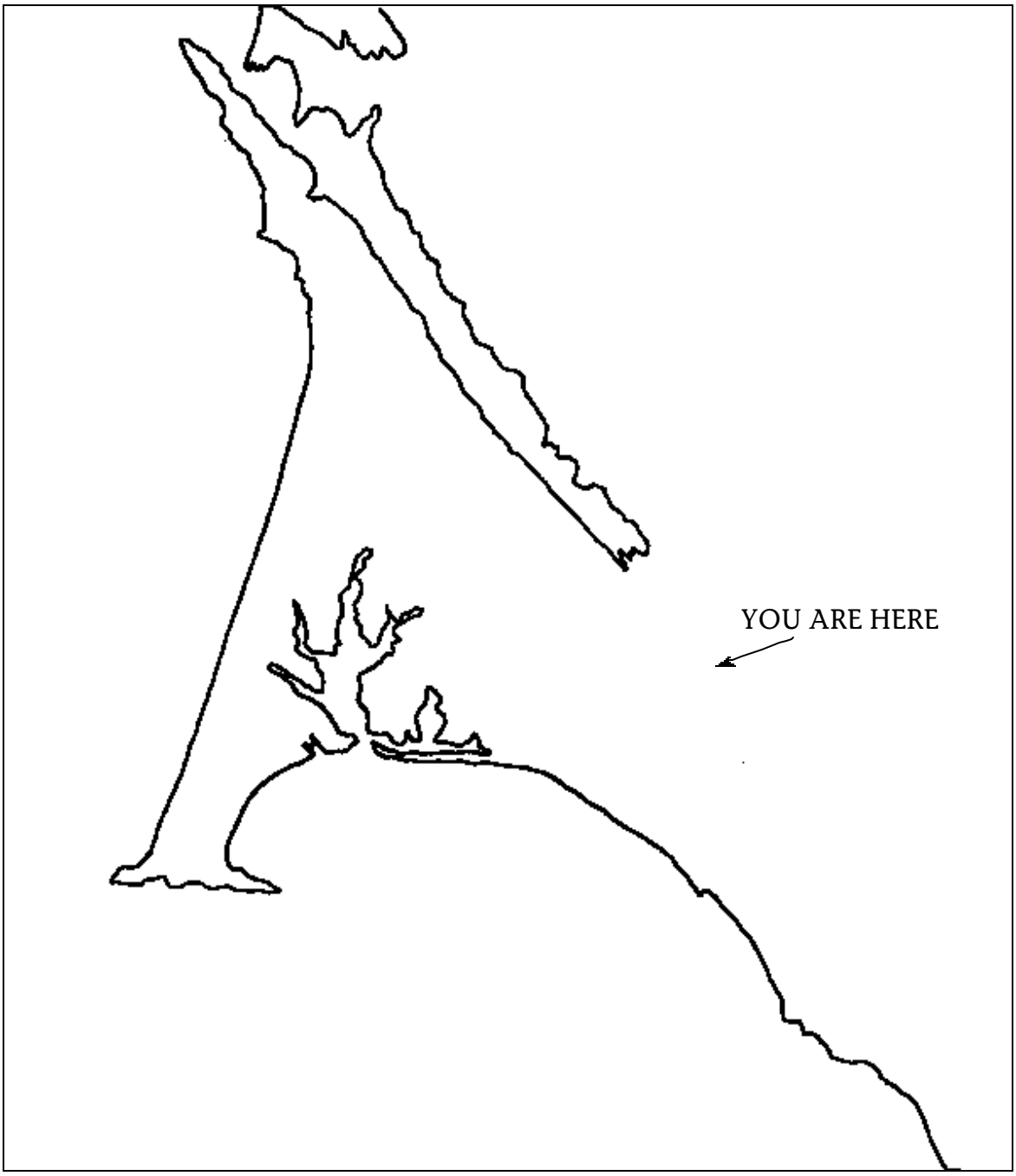
Ticks

Ticks carrying Lyme disease are found at Point Reyes National Seashore. Check your body after a hike. Wear light-colored long pants and shirts to help find ticks. Tuck your pant legs into your socks.

Bear Valley Visitor Center Activity

Using the three-dimensional relief map in the Visitor Center and the official Park brochure located at the information desk, label the following topographical features on the map below:

San Andreas Fault
Inverness Ridge
Mount Wittenberg
Tomales Bay
Mount Vision
Bolinas Lagoon
Drakes Estero
Pacific Plate (west of the San Andreas Fault)
North American Plate (east of the San Andreas Fault)



Field Journal Sheet

Bear Valley Visitor Center Activity

Briefly write down some ideas as to how you think the San Andreas Fault has influenced the landforms across the Point Reyes Peninsula.

In one column, list ideas for how it has influenced landforms in the past and in the other, list how the fault may influence landforms in the future. Use your best guesses and creativity for answers.

	In the Past	In the Future
Ridges and Mountains	Example: • previously flat areas became raised as the fault moved	• ridges and mountains may continue to get higher
Valleys		
Bays and Lagoons		
Esteros		

Introduction Sign

What are two questions you have about the San Andreas Fault or the 1906 earthquake? Write these below:

1.

answers will vary

2.

Look closely at the three-dimensional map.
List two noticeable landforms that you think are caused by the San Andreas Fault. HINT: Look closely at the map's outline and elevations.

1.

Examples of landforms caused by fault:

- ***valley surrounding fault formed***
- ***peninsula formed along fault line***
- ***Tomales Bay formed along fault line***
- ***Bolinas Lagoon formed along fault line***

2.

Note:
The eastern boundary of Tomales Point is parallel to the San Andreas Fault.
Bolinas Lagoon and Tomales Bay represent submerged blocks of the fault.
Mountain ridges are located on either side of the San Andreas Fault.

Earthquake Trail

What happened during the 1906 earthquake?

Choose one photograph from this board to answer the following questions:

Briefly describe the photo:

Display has various photos of a toppled train, offset road, destroyed entrance gates to Stanford University, destroyed homes, fires.

Answers below will vary.

How were people affected in this photo?

Can you think of anything that could be done to prevent this situation from happening in the future?

The San Andreas Fault

The fault zone creates a depression surrounded by hills on both sides. How do you think this fault zone affects the strength of rocks making up the hills on both sides?

Rocks surrounding a fault zone can crack and form joints. This type of cracking can lead to a type of erosional feature called "melted ice cream topography."

How does the fault zone affect the strength of rocks within the zone?

The fact that the fault zone is a depressed valley suggests that the rocks are weaker in this area. Rocks in the fault zone are weakened by the grinding of the North American Plate and the Pacific Plate.

Can the San Andreas Fault swallow cities?

How has this land healed since the last big earthquake? Compare the photos of the past with what you see before you on the landscape?

The crack has been filled in by erosion and deposition. Loose soil from surrounding areas was transported during heavy rains and deposited in the crack.

Erosion has smoothed the surface and there has been deposition of sediment into the cracks. In this area erosion occurs rapidly due to the weather (moist climate and vegetation). In the desert features like the crack formed by faulting would remain intact much longer.

How might the land have been different if the surface were solid granite?

Answers will vary.

The surface might have
- ***split leaving a jagged cliff along the crack.***
- ***increase the area effected by the earthquake, the granite would cause the waves to travel further.***

What are some ways that media (newspapers, television, etc.) affect stories being told about earthquakes?

Answers will vary.

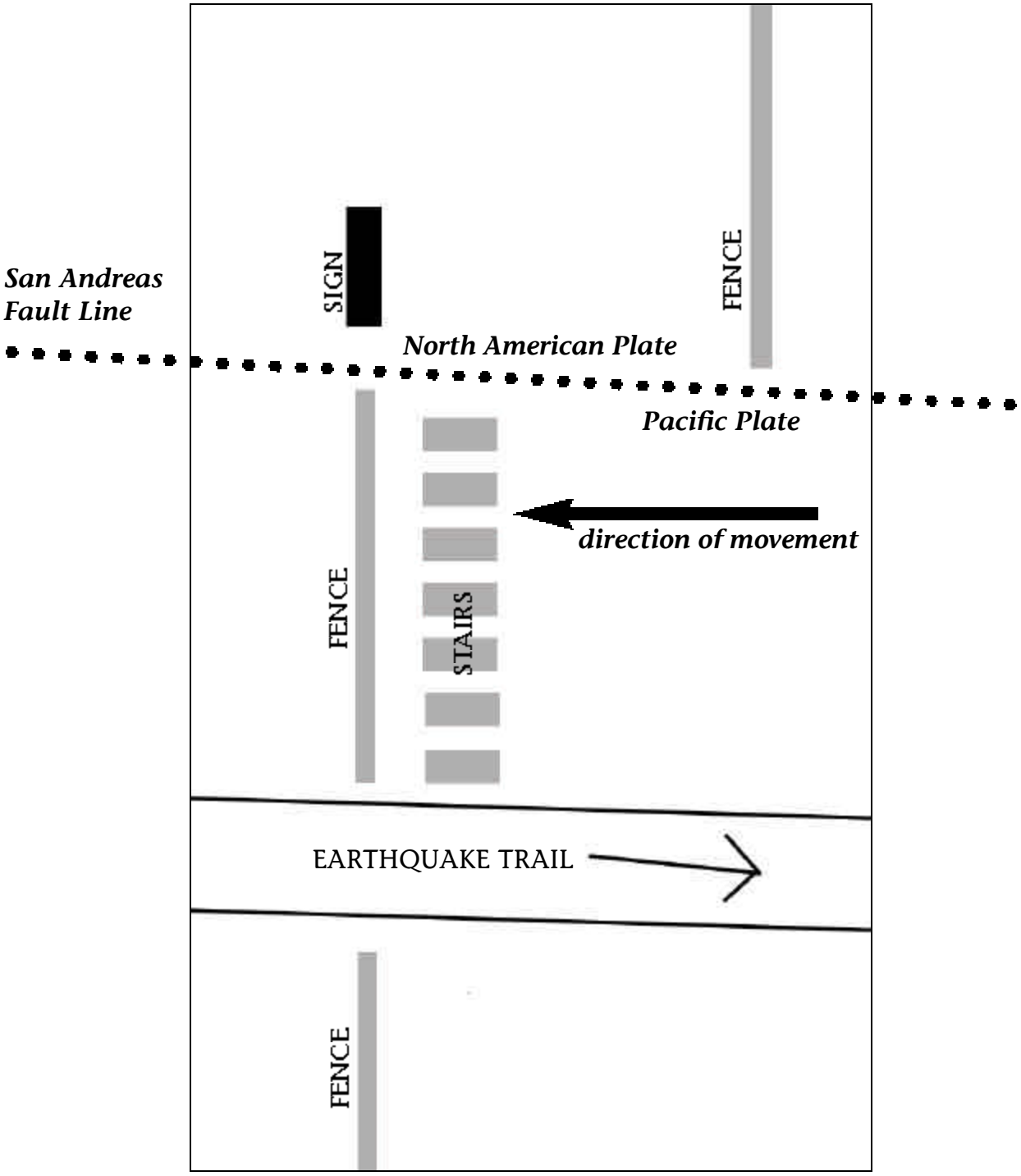
The media may
- ***help people prepare for aftershocks or avoid areas of heavy damage.***
- ***help mobilize people such as doctors, firefighters, Red Cross workers etc., to assist with emergency situations.***
- ***sensationalize stories of people and things that happen during earthquakes - such as the "cow in the crack" story at Point Reyes.***

Displaced Fence

Orient yourself to the map below. Look for the trail, the fence, and the stairs.
Draw and label on the map:

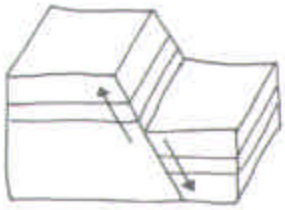
San Andreas Fault Line Pacific Plate North American Plate

Also, draw arrows to indicate which direction each plate is moving.

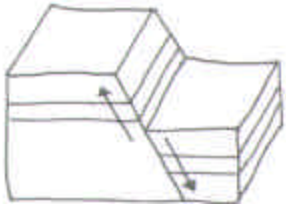


Displaced Fence

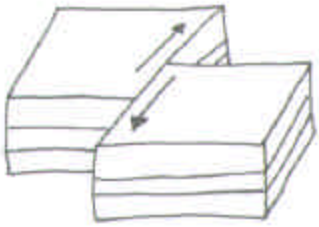
Based on your observations of this area, what type of fault is the San Andreas? Circle your answer below:

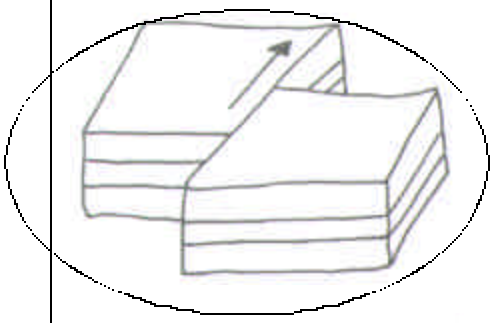


Normal Fault: One block will drop or rise against the other block as a result of stretching that breaks rocks along a steep fault plane.

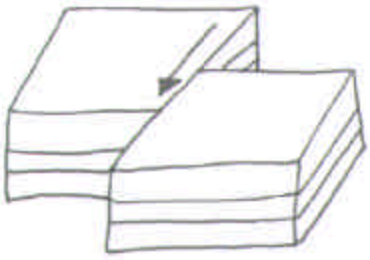


Reverse Fault: One block is forced up and the other block is forced down.





The San Andreas Fault is a transform, right lateral strike-slip fault. If you were standing on the North American Plate facing the Pacific Plate (for millions of years), you would see a horizontal shearing with the Pacific Plate moving northwest along the North American Plate.



Left Strike-Slip: Same as Right Strike-Slip, but to the left.

Why are the rocks different on either side of the fault?

What kinds of rocks are on the eastern side of the fault?

Mostly Franciscan rocks: the Franciscan Franciscan Complex is a series of rocks that were formed in the DEEP ocean then jumbled, altered, shoved up, and attached to the North American plate.

What kinds of rocks are on the western side of the fault?

Mostly granitic rocks and some sedimentary rocks (such as the Lighthouse conglomerate and Drakes Beach cliffs.)

Why are these two different rock types next to one another at Point Reyes National Seashore?

Because there are two different plates which meet here and at this boundary the rock types are different.

In addition, the San Andreas Fault is the active boundary between these two different plates. The rocks on each side of the fault were formed at different places under different conditions and movement along the fault has brought the Point Reyes Peninsula to this position adjacent to the coastal ranges.

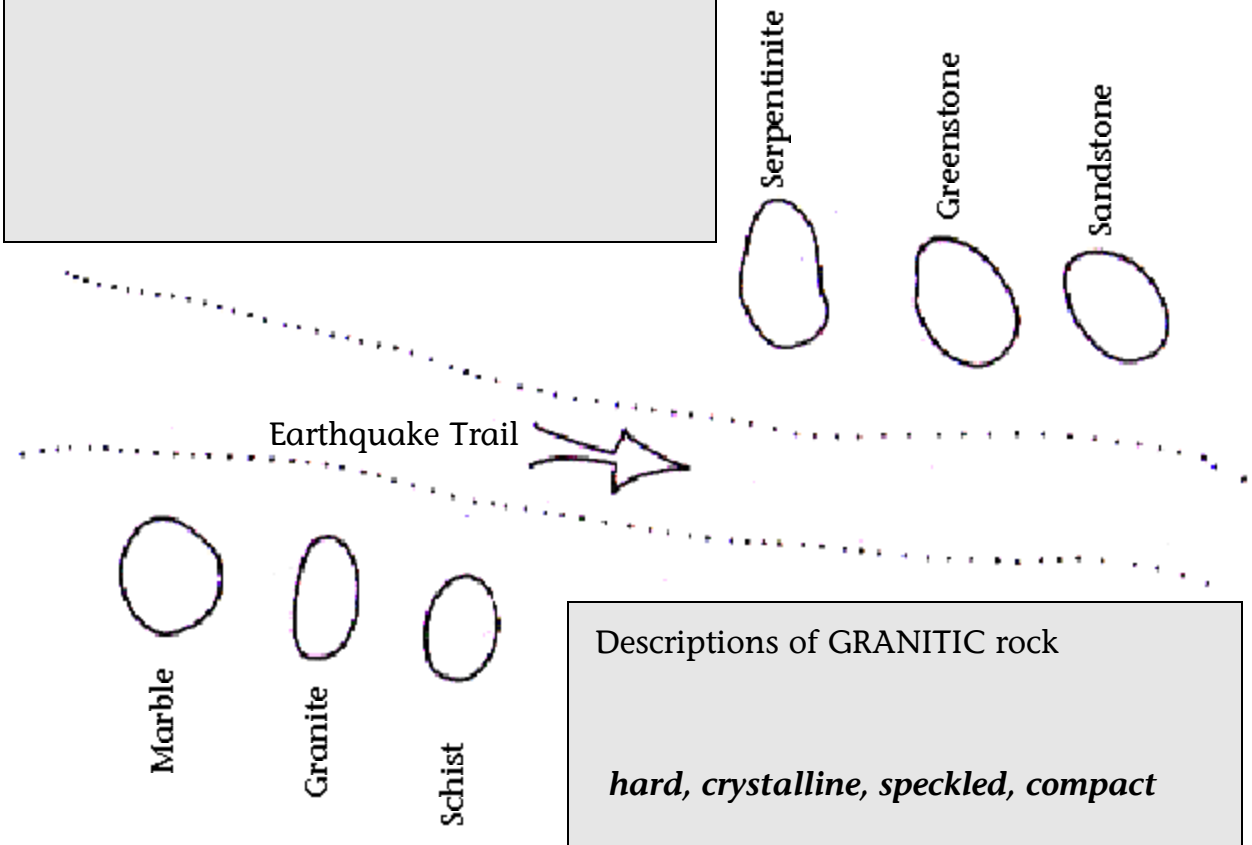
Earthquake Trail

Franciscan Rocks

Choose one rock to observe on each side of the path. What is the grain size, texture, coloration? How do the two rocks that you choose to observe compare to each other? Are they more alike or more different? List one difference between the rocks on either side of the path.

Descriptions of FRANCISCAN rock

soft, flaky, layered, green, ocean origin



Descriptions of GRANITIC rock

hard, crystalline, speckled, compact

Continents drift because of moving plates

What are the names of the two lithospheric plates that form the San Andreas Fault?

North American Plate ***Pacific Plate***

List three geologic processes that happen on plate boundaries.

1.

r

2.

Examples:
rising mountain ranges
subsiding ocean trenches
active volcanoes
earthquakes

3.

How do you think the climate and ecology on the Point Reyes Peninsula will change in 50 million years?

It will most likely get colder from moving north, daylight/darkness cycles will change, hills may become eroded to flatlands, individual plants will either survive or die in the changes (creating new habitats).

Earthquake Trail

Continental Drift Timetable

Where will Point Reyes National Seashore be in 40 million years?

Point Reyes will eventually become an island, isolating the plants and animals from the continent. As the climate changes, many of the plants and animals may die unless they can adapt to the changes. New plants and animals may appear if they are better adapted to the new climate.

If Point Reyes National Seashore and the land containing Los Angeles and Baja California are separated by water, why are they moving together?

Because they are on the same plate which encompases both land and water between Point Reyes, Los Angeles, and Baja California.

How will Point Reyes National Seashore change as a result of plate tectonics? What do you think will happen to the plants and animals of the Peninsula as these changes happen?

Answers will vary.

Earthquake Trail

Moving plates cause earthquakes...a continuing process

How are earthquakes created?

Earthquakes are the result of sudden movements along a fault.

Why are there so many earthquakes in California?

Because the San Andreas Fault SYSTEM trends in a northwesterly direction through much of western California. The fault system is the active boundary between the Pacific and North American plate and the faults that make it up (primarily the San Andreas Fault) collectively accommodate the relative motion between the two plates.

Write a definition of the San Andreas Fault.

An active transform fault, the active boundary between the Pacific and North American plates.

Earthquake Trail

Occasional small quakes won't prevent big ones!

How many 5.3 magnitude earthquakes does it take to equal the power of the 1906 earthquake?

30,000

Why don't occasional small earthquakes prevent BIG ONES from happening?

Smaller earthquakes release only a fraction of the energy of large earthquakes,therefore it would take an excess of many small earthquakes to equal the energy that is being released in one large one.

How the geology performed during the 1906 earthquake

Locate your home on the "Active Faults of the San Francisco Bay Area" map." What kind of land is it built on?

Answers will vary.

Is this type of land resistant to earthquakes or easily damaged during earthquakes?

Answers will vary.

Based on this map, would it be safe to build a home on the immediate banks of the San Francisco Bay? Why or why not?

No, the soil is unstable.

Earthquake Trail

Are you prepared for the next earthquake?

Circle the correct answer.

True (False) — After an earthquake, immediately go outside to take photos.

(True) False — You should prepare an Earthquake Kit with a first aid kit, food, water, and a portable radio.

(True) False — When you are outside, be aware of your surroundings and avoid falling objects and live electrical wires.

True (False) — During an earthquake, seek shelter under a window so that you can monitor damage in your area.

Introduction Sign

What are two questions you have about the San Andreas Fault or the 1906 earthquake? Write these below:

1.

2.

Look closely at the three-dimensional map.
List two noticeable landforms that you think are caused by the San Andreas Fault. HINT: Look closely at the map's outline and elevations.

1.

2.

Field Journal Sheet

Earthquake Trail

What happened during the 1906 earthquake?

Choose one photograph from this board to answer the following questions:

Briefly describe the photo:

How were people affected in this photo?

Can you think of anything that could be done to prevent this situation from happening in the future?

The San Andreas Fault

The fault zone creates a depression surrounded by hills on both sides.
How do you think this fault zone affects the strength of rocks making up the hills on either side of the fault?

How does the fault zone affect the strength of rocks within the zone?

Field Journal Sheet

Earthquake Trail

Can the San Andreas Fault swallow cities?

How has this land healed since the last big earthquake? Compare the photos of the past with what you see before you on the landscape.

How might the land have been different if the surface were solid granite?

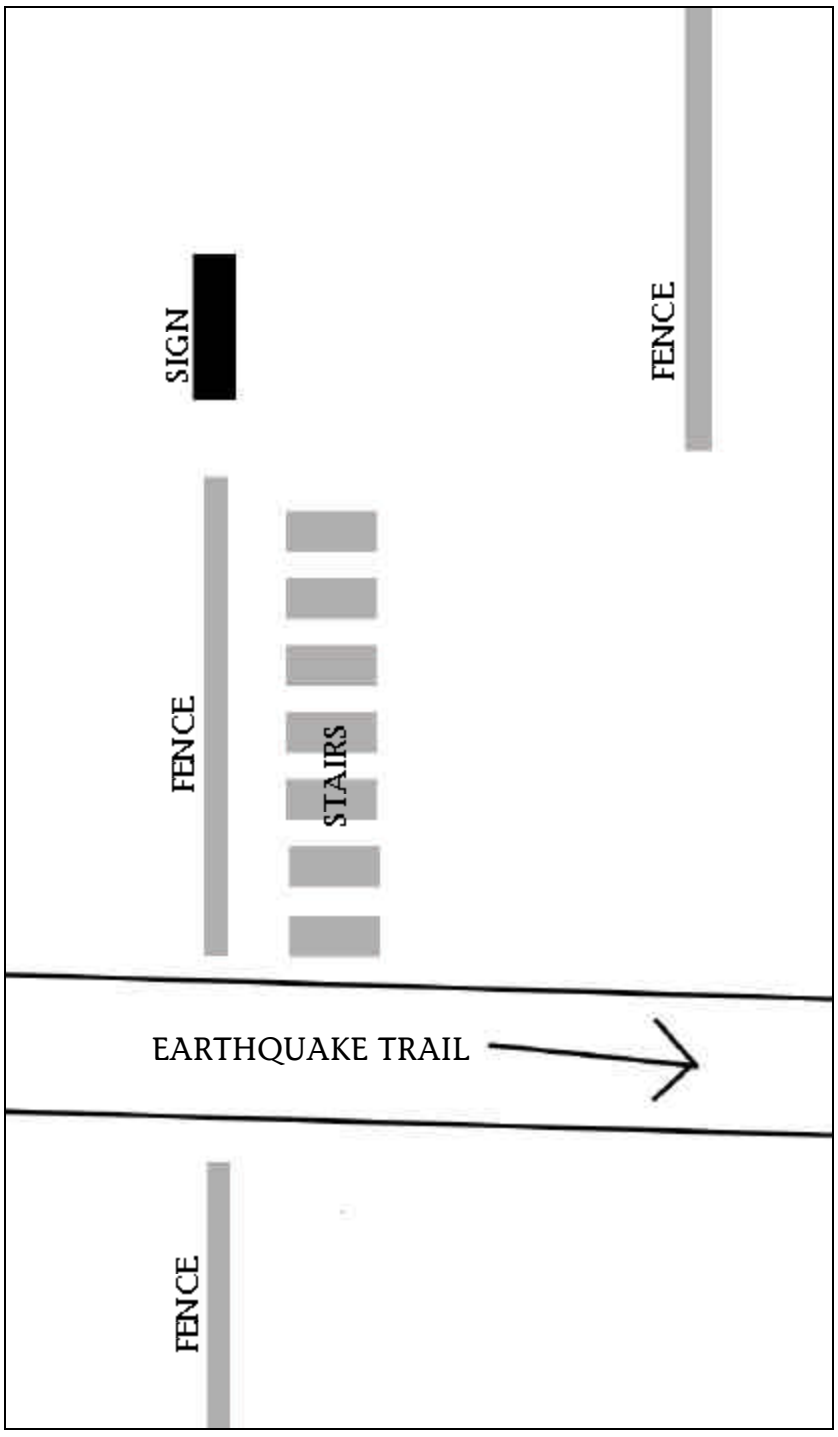
What are some ways that media (newspapers, television, etc.) affect stories being told about earthquakes?

Displaced Fence

Orient yourself to the map below. Look for the trail, the fence, and the stairs.
Draw and label on the map:

San Andreas Fault Line Pacific Plate North American Plate

Also, draw arrows to indicate which direction each plate is moving.

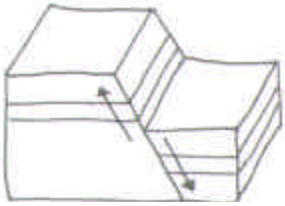


Earthquake Trail

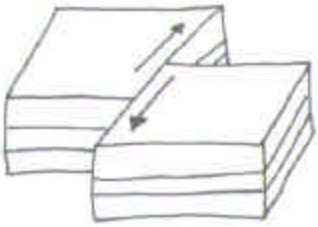
Displaced Fence

Based on your observations of this area, what type of fault is the San Andreas? Circle your answer below:

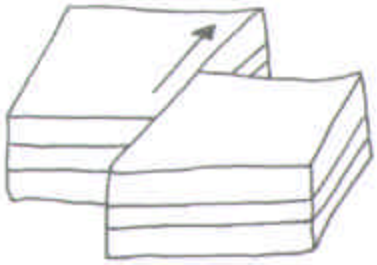
Normal Fault: One block will drop or rise against the other block as a result of stretching that breaks rocks along a steep fault plane.



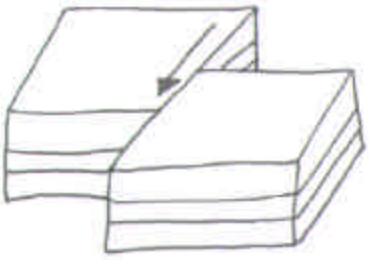
Reverse Fault: One block is forced up and the other block is forced down.



Strike-Slip or Slip-Strike: Horizontal shearing along a vertical plane (also known as Tear Fault, Transform Fault, Transcurrent Fault, or Wrench Fault).



Right Slip-Strike: Horizontal shearing along a vertical plane in which one plate moves to the right (if you were standing on the plate with no movement, the other plate would move to your right).



Left Slip-Strike: Same as Right Slip-Strike, but to the left.

Field Journal Sheet

Earthquake Trail

Why are the rocks different on either side of the fault?

What kinds of rocks are on the eastern side of the fault?

What kinds of rocks are on the western side of the fault?

Why are these two different rock types next to one another at Point Reyes National Seashore?

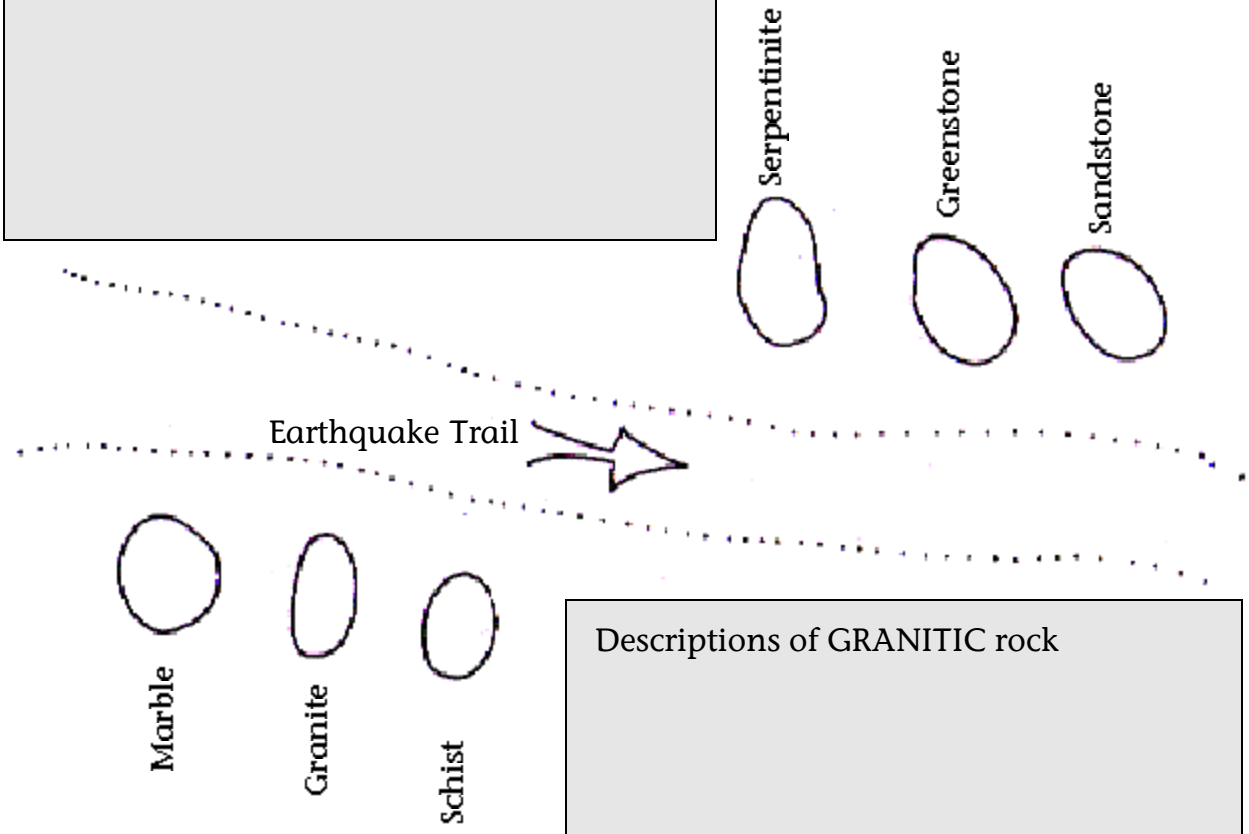
Field Journal Sheet

Earthquake Trail

Franciscan Rocks

Choose one rock to observe on each side of the path. What is the grain size, texture, coloration? How do the two rocks that you choose to observe compare to each other? Are they more alike or more different? List one difference between the rocks on either side of the path.

Descriptions of FRANCISCAN rock



Descriptions of GRANITIC rock

Continents drift because of moving plates

What are the names of the two lithospheric plates that form the San Andreas Fault?

_____ _____

List three geologic processes that happen on plate boundaries.

1.

2.

3.

How do you think the climate and ecology in California will change in 50 million years?

Field Journal Sheet

Earthquake Trail

Continental Drift Timetable

Where will Point Reyes National Seashore be in 40 million years?

If Point Reyes National Seashore and the land containing Los Angeles and Baja California are separated by water, why are they moving together?

How will Point Reyes National Seashore change as a result of plate tectonics? What do you think will happen to the plants and animals of the Peninsula as these changes happen?

Earthquake Trail

Moving plates cause earthquakes...a continuing process

How are earthquakes created?

Why are there so many earthquakes in California?

Write a definition of the San Andreas Fault.

Field Journal Sheet

Earthquake Trail

Occasional small quakes won't prevent big ones!

How many 5.3 magnitude earthquakes does it take to equal the power of the 1906 earthquake?

Why don't occasional small earthquakes prevent BIG ONES from happening?

Earthquake Trail

How the geology performed during the 1906 earthquake

Locate your home on the "Active Faults of the San Francisco Bay Area" map." What kind of land is it built on?

Is this type of land resistant to earthquakes or easily damaged during earthquakes?

Based on this map, would it be safe to build a home on the immediate banks of the San Francisco Bay? Why or why not?

Field Journal Sheet

Earthquake Trail

Are you prepared for the next earthquake?

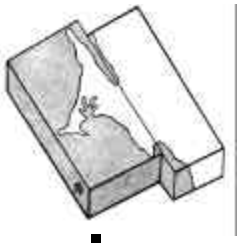
Circle the correct answer.

True False After an earthquake, immediately go outside to take photos.

True False Prepare an Earthquake Kit with a first aid kit, food, water, and a portable radio.

True False When you are outside, be aware of your surroundings and avoid falling objects and live electrical wires.

True False During an earthquake, seek shelter under a window so that you can monitor damage in your area.



What Does a Fault Zone Look Like?

Students visit the top of Mount Vision, where it is possible to see the San Andreas Fault zone along Tomales Bay. From this overlook it is also possible to see the mountains of the Coast Range as well as see a good overview of the Point Reyes Peninsula. Guided activity sheets help students understand how the San Andreas Fault Zone and Marin County's rock types shape the local topography.

Special note: Call ahead for weather. This lesson is impossible if fog or low clouds obscure the view from the top of Mount Vision. September and October generally have the least fog.
Hiking option: Use Limantour Road to access Bayview Trailhead. Follow the Inverness Ridge Trail to the Mount Vision Overlook. It is about 3 miles (one-way) and 4-6 hours (round-trip) from the trailhead depending on the pace of walking.
Driving option: Take Sir Francis Drake Boulevard to Mount Vision Road. It is about a 30-minute drive from the Bear Valley Visitor Center (cars only)
Suggested group size: Individual hiking groups should not exceed 50 people.
Subjects: earth science, art
Concepts covered: faults, rock types of Marin County, interpretive geology
Written by: Don Jolley, Teacher, Bolinas School, Bolinas
Last updated: 04/02/00

Student Outcomes

At the end of this activity, students will be able to:

- Identify the geologic features of the San Andreas fault zone
- Explain how underlying rock types create different land formations
- Explain the basic geologic history of local landforms

California Science Standard Links (grades 6-8)

This activity is linked to the California Science Standards in the following areas:

6th grade: 1a - the fit of the continents, location of earthquakes, etc., provide evidence for plate tectonics

1d - earthquakes are sudden motions along breaks in the crust called faults
1e - major geologic events, such as earthquakes, volcanic eruptions, and mountain building result from plate tectonics
1f - explain major features of California geology in terms of plate tectonics (including mountains, faults, volcanoes)
7b - select and use appropriate tools and technology to perform tests, collect and display data
7f - read a topographic map and a geologic map for evidence provided on the maps, and construct and interpret a simple map
7g - interpret events by sequence and time from natural phenomena
7h - identify natural changes in natural phenomena over time without manipulating the phenomena

7th grade: 7a - select and use appropriate tools and technology to perform tests, collect and display data
7e - communicate the steps and results from an investigation

8th grade: 9b - evaluate the accuracy and reproducibility of data

National Science Standard Links (grades 5-8)

This activity is linked to the National Science Standards in the following areas:

- Content Standard A - Use appropriate tools and techniques to gather, analyze, and interpret data; Think critically and logically to make the relationships between evidence and explanations.
- Content Standard B - Motions and forces; Transfer of energy.
- Content Standard D - Earth's history.

Materials

To be provided by the student:

- hiking shoes, lunch, water

To be photocopied from this guide:

- **What Does a Fault Zone Look Like?** Field Journal Sheets
- **The San Andreas Fault-Point Reyes** Teacher Information Sheet

To be picked up at the Bear Valley Visitor Center:

- Point Reyes National Seashore map (free at desk)
- Geology Backpack, binoculars, spotting scope, clipboards

Vocabulary

basalt, chert, erosion, fault zone, Franciscan Complex, topography, transform fault, uplift, weathering

Procedures

1. **Teacher review and preparation**
   Review **The San Andreas Fault-Point Reyes** Teacher Information Sheet to prepare for your field trip.

2. **At the Mount Vision Overlook**
   Drive or hike to the Mount Vision Overlook. Allow time for students to observe the topography. Designate a timeframe to complete the **What Does a Fault Zone Look Like?** Field Journal Sheet. They should be able to identify the major features shown on the map by using the Point Reyes brochure.

3. **Summary**
   There are four major geologic features that students should locate:

   A. East of the Fault Zone is the **coast range mountains**. From the top of Mount Vision, one can see Mount Barnaby, Mount Black, Bolinas Ridge and Mount Tamalpais. Mountains in this range are underlaid by basalt and chert. These mountains have been pushed up, or uplifted, by forces from the San Andreas Fault. The hardness and resistance (to weathering and erosion) of these rocks also help to account for their relatively high elevations.

   B. Interspersed in the Coast Range are the rolling hills of the **Franciscan Complex**. These hills are underlaid by a mixture of deep-sea sediments, primarily sandstone. The high permeability of these rocks weakens them and makes them highly susceptible to erosion and land slides. Sometimes the many chunks of land that have slid down create a look known as "melted ice cream topography."

   C. East of Point Reyes is the **San Andreas Fault Zone**. This can be seen as a low-lying valley which includes Tomales Bay, Bolinas Lagoon, and much of San Francisco Bay. The grinding of the Pacific and North American Plates weakens the rocks in this area, making them susceptible to erosion and creating a depression in the topography.

   D. The **mountains of Point Reyes** are shaped from granite, which has been displaced to the north by the motion of the Pacific Plate. The hardness and resistance to erosion of granite make these mountains (including Mount Vision) relatively high.

Extension Ideas

1. Drive south on Highway 1 along the fault zone. This parallels the Rift Zone and Olema Valley trails in the park. Look for sag ponds along the road. Past Five Brooks on the south side of the road there are two creeks that flow in different directions parallel to eachother. Pine Gulch Creek flows south and Olema Creek flows north. At Bolinas Lagoon the fault runs under the water. Along the cliffs of Highway 1 overlooking Stinson Beach there are many outcrops of serpentine, which is a dominant rock type in the Franciscan Complex. Serpentine is a greenish blue mineral that has a "waxy" appearance, this mineral is abundant in the rocks because they were formed in the deep ocean

the altered as they were brought to the surface and attached to the North American plate.

2. Find pictures of other areas of the San Andreas Fault Zone and compare them to the area around Point Reyes. In southern California there are desert areas where the fault is seen clearly by offset mountains and streams.

The world-famous San Andreas Fault separates the Point Reyes peninsula from the main land of California. The fault is much more than a simple boundary. It has created the landscape of this area with its long bays and lagoons and the narrow Olema Valley. It looms and promises to change the landscape again with the next big earthquake. Will the "Big One" be today, next week, or five years from now? It's a hard question to answer because there is so much that is still not known about earthquakes and seismic activity. However, it is known that the earthquakes we experience are cause by the shifting and movements of the vast plates that cover the earth some of which we live on.

Think Big, Think Plate Tectonics

To understand the San Andreas Fault, we must leave the Olema Valley to examine the larger global theory Plate Tectonics. Geologists believe that the outer layer of the earth is segmented into about a dozen rigid plates. These plates which are up to 62 miles thick, float on a fluid layer of molten earth. Currents within this layer slowly move and shift the surface plates that we live on. This movement causes plates to collide in convergent plate boundaries, to separate in divergent plate boundaries or slide past one another in transform plate boundaries. Where these plates meet, boundaries are the site where mountains are created, volcanoes erupt, and earthquakes occur.

The San Andreas Fault is a transform plate boundary that separates the two largest plates in the world, the Pacific and North American plates. The oceanic Pacific plate, which includes Point Reyes, is slowly grinding to the northwest at about two inches per year in relation to the North American plate. This movement is responsible for the topography of the area as well as the frequent earthquakes of varying magnitude.

Hop a Ride on the Pacific Plate

Visitors to Point Reyes National Seashore will enter the San Andreas Fault zone and cross from the North American to the Pacific plate. Even though the Point Reyes peninsula is currently attached to the mainland, in many ways you have set foot onto a land in motion. The peninsula is thought to have traveled 280 miles over the last 30 million years from its origins near Los Angeles.

Not Soon Forgotten

During the brief presence of humans along the fault, the San Andreas has played a significant role in human history. Perhaps the most famous earthquake in the western world occurred the San Francisco Bay Area on

April 18, 1906. When the earthquake struck, the Point Reyes Peninsula jolted northwest about 20 feet (6 meters). In nearby San Francisco, fires resulting from the earthquake crippled the city causing millions of dollars of damage and hundreds of deaths.

On October 17,1989, San Francisco Bay Area residents were again reminded of the power of the San Andreas and its adjacent faults. The Loma Prieta Earthquake, whose epicenter was in the Santa Cruz Mountains, caused the collapse of a portion of the Bay Bridge, a freeway overpass in Oakland and many other structures.

What Does a Fault Zone Look Like?

From the top of Mount Vision you can see the coast, Inverness Ridge, the San Andreas Fault Zone, and the mountains of the Coast Range. Pick a spot where you have a great view, and make two separate drawing of what you see - one with the view to the east, and one with the view to the west. Identify each of these features on your drawing by writing the names next to the corresponding feature on your map. Use the Point Reyes map to help you.

The Pacific Ocean	Mount Vision	Tomales Bay
Mount Barnaby	Mount Black	Bolinas Lagoon
Mount Tamalpais	Bolinas Ridge	Drakes Estero
San Andreas Fault Zone		

After sketching and labeling the two views on the blank sheets following these instructions, answer the following questions.

1. Why is Tomales Bay so straight? Compare it with the shape of Drakes Estero (estero is the Spanish word for estuary). What could account for their different shapes, in terms of their origin?

Tomales Bay lies directly in the San Andreas Fault Zone. Its straight shape mirrors the shape of the fault. Drakes Estero does not lie on the fault. Its branching shape forms as the water in the estuary seeks natural, randomly spaced weakness in the rocks. The area forming Drakes Estero has also been pushed below sea level by forces from the San Andreas Fault. The area is part of the Point Reyes Syncline.

2. Why are the Olema Valley and Tomales Bay topographically so low? What important feature runs through this area? What does this depression suggest about the strength of the rocks in this area? Why is the rock strength different in this area?

The Olema Valley and Tomales Bay are located on the San Andreas Fault Zone. The fault zone depresses the valley in two major ways. One, pressure from fault motion pushes blocks of rock upward, resulting in the mountains on either side of the fault zone. The actual process that causes the uplift is complex. In simple terms, slight bends in the direction of the fault line result in compression instead of strike slip motion. The compression squeezes rock against rock until it is finally forced upward. Two, the grinding of the North American and Pacific Plates weakens the rocks in the fault zone, making them more succeptible to erosion. The weakening of rock due to motion along the fault is easier to understand - this is the point that should be stressed for most students.

3. Notice the shape of the rolling hills to the east in the Roast range. The rocks under these hills are known as the Franciscan Melange). Their rounded, bulging shape is sometimes referred to as "wet ice cream topogaphy" because their shape resembles that of melting ice cream. What does this shape suggest about the Franciscan rock's resistance to weathering and erosion?

The bulges in the hills are the result of landslides. A close look at the bulges reveals how various segments of the hillsides have slipped down over time. This is because the Franciscan melange is a relatively weak rock that has a high porosity and weathers easily. The bulges are from resistant blocks in the Franciscan Melange that stay together during landslides. Before a landslide, the ground becomes saturated with water. If excess water cannot be absorbed in the soil and rock, it creates smooth surfaces for chunks of land to slip over. (Students who live in Marin will probably be familiar with the many landslides that occur in this area).

4. What might account for the fact that certain features (i.e., Mount Black, Mount Tamalpais, Bolinas Ridge, Mount Vision you're standing on) rise above the Franciscan Melange? Consider the differences between hard and soft rock, and how this affects erosion.

The raised topography of certain features shows that they contain harder, more resistant rocks. In the Coast Range, chert and greenstone tend to underlie the highest peaks, and on Point Reyes, granite underlies these features. The mountains themselves have been uplifted by pressure from the San Andreas Fault as explained in Question 2.

What Does a Fault Zone Look Like?

From the top of Mount Vision you can see the coast, Inverness Ridge, the San Andreas Fault Zone, and the mountains of the Coast Range. Pick a spot where you have a great view, and make two separate drawing of what you see - one with the view to the east, and one with the view to the west. Identify each of these features on your drawing by writing the names next to the corresponding feature on your map. Use the Point Reyes map to help you.

The Pacific Ocean	Mount Vision	Tomales Bay
Mount Barnaby	Mount Black	Bolinas Lagoon
Mount Tamalpais	Bolinas Ridge	Drakes Estero
San Andreas Fault Zone		

After sketching and labeling the two views on the blank sheets following these instructions, answer the following questions.

1. Why is Tomales Bay so straight? Compare it with the shape of Drakes Estero (estero is the Spanish word for estuary). What could account for their different shapes, in terms of their origin?

2. Why are the Olema Valley and Tomales Bay topographically so low? What important feature runs through this area? What does this depression suggest about the strength of the rocks in this area? Why is the rock strength different in this area?

Field Journal Sheet

3. Notice the shape of the rolling hills to the east in the Coast Range. The rocks under these hills are known as the Franciscan Melange.) Their rounded, bulging shape is sometimes referred to as "wet ice cream topogaphy" because their shape resembles that of melting ice cream. What does this shape suggest about the Franciscan rock's resistance to weathering and erosion?

4. What might account for the fact that certain features (i.e., Mount Black, Mount Tamalpais, Bolinas Ridge, Mount Vision you're standing on) rise above the Franciscan Melange? Consider the differences between hard and soft rock, and how this affects erosion.

Field Journal Sheet

My View Looking East

Draw the prominent features of the topography and identify the symbols in your map key.

Map Key

Field Journal Sheet

My View Looking West

Draw the prominent features of the topography and identify the symbols in your map key.

Map Key